

***Remedy Performance  
Summary Report for the Final  
Groundwater Remediation  
Operable Unit 1-07B,  
Fiscal Year 2002***

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**Idaho  
Completion  
Project**

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Bechtel BWXT Idaho, LLC

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# **Remedy Performance Summary Report for the Final Groundwater Remediation Operable Unit 1-07B, Fiscal Year 2002**

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## **ABSTRACT**

The Annual Remedy Performance Monitoring Report for 2002 describes the overall performance of the groundwater restoration remedy at Operable Unit 1-07B at the Idaho National Engineering and Environmental Laboratory. This report summarizes important activities completed this year for each of the three remedial action components included in this study: in situ bioremediation, the New Pump and Treat Facility, and monitored natural attenuation. Integration of the three components is discussed, as well as their combined effectiveness at remediating the groundwater plume at Test Area North.

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## ACRONYMS

AED	alternate or alternative electron donor
ARD	anaerobic reductive dechlorination
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	contaminant of concern
DCE	dichloroethene
DOE	Department of Energy
DOE-ID	Department of Energy Idaho Operations Office
DQO	data quality objective
FLUTE™	Flexible Liner Underground Technology
FY	fiscal year
ICDF	INEEL CERCLA Disposal Facility
INEEL	Idaho National Engineering and Environmental Laboratory
ISB	in situ bioremediation
MCL	maximum contaminant level
MNA	monitored natural attenuation
NPTF	New Pump and Treat Facility
OU	operable unit
PCE	tetrachloroethene
PDO	Predesign Operations
PDP	Predesign Phase
RAO	remedial action objective
RD/RA	Remedial Design/Remedial Action
ROD	Record of Decision
SP	sampling port
SVOC	semivolatile organic compound

TAN	Test Area North
TBD	to be determined
TCE	trichloroethene
TSDF	Treatment Storage and Disposal Facility
TSF	Technical Support Facility
USGS	United States Geological Survey
VOC	volatile organic compound

# Remedy Performance Summary Report for the Final Groundwater Remediation Operable Unit 1-07B, Fiscal Year 2002

## 1. INTRODUCTION

Operable Unit (OU) 1-07B at the Idaho National Engineering and Environmental Laboratory (INEEL) is the site of a contaminated groundwater plume that extends nearly two miles from the historic Technical Support Facility (TSF)- 05 injection well at the Test Area North (TAN) facility. Contaminants of concern (COCs) and pre-remedial action concentrations in the vicinity of TSF-05 are listed in Table 1-1. Due to the size of the plume and complexity of the site conditions, the remedial action was designed with three distinct technologies: (a) including enhancing dechlorination of TCE and other chlorinated volatile organic compounds (VOCs), (b) active groundwater extraction and treatment, and (c) monitoring the rate of natural attenuation. The three corresponding remedy components are referred to as in situ bioremediation (ISB), the New Pump and Treat Facility (NPTF), and monitored natural attenuation (MNA). Each component was designed with specific objectives to target distinct portions of the plume.

Table 1-1. Contaminants of concern in the vicinity of the TSF-05 injection well.

Contaminant	Maximum Concentration Range"	Federal Drinking Water Standard
Volatile Organic Compounds		
Trichloroethene (TCE)	12,000 – 32,000 ppb	5 ppb <sup>b</sup>
Tetrachloroethene (PCE)	110 ppb	5 ppb <sup>b</sup>
cis-1,2-Dichloroethene (DCE)	3,200 – 7,500 ppb	70 ppb <sup>b</sup>
trans-1,2-DCE	1,300 – 3,900 ppb	100 ppb <sup>b</sup>
Radionuclides		
Tritium	14,900 – 15,300 pCi/L <sup>c</sup>	20,000 pCi/L
Strontium-90	530 – 1,880 pCi/L	8 pCi/L
Cesium-137	1,600 – 2,150 pCi/L	119 pCi/L <sup>d</sup>
Uranium-234	5.2 – 7.7 pCi/L <sup>e</sup>	27 pCi/L <sup>e</sup>

ppb = parts per billion

pCi/L = picocuries per liter.

a. The concentration range is taken from measured groundwater concentrations at the TSF-05 injection well (INEEL 2000).

b. ppb is a weight-to-weight ratio that is equivalent to micrograms per liter (µg/L) in water.

c. Maximum concentrations of tritium and U-234 are below federal drinking water standards, and baseline risk calculations indicate cancer risk of  $3 \times 10^{-6}$ . While this risk is smaller than  $1 \times 10^{-4}$ , both tritium and U-234 are included as COCs as a comprehensive plume management strategy.

d. The maximum contaminant level for Cs-137 is derived from a limit of 4 millirem per year (mrem/yr) cumulative dose-equivalent to the public, assuming a lifetime intake of 2 liters per day (L/day) of water.

e. The federal drinking water standard for U-234 is for the U-234, -235, and -238 series.

The purpose of this report is to present a summary of the overall performance of the OU 1-07B remedial action project. As required in the *Remedial Design/Remedial Action Scope of Work Test Area North Final Groundwater Remediation Operable Unit 1-07B* (Department of Energy Idaho Operations Office (Department of Energy Idaho Operations Office [DOE-ID] 2001a), regulatory performance and compliance with remedial action objectives (RAOs), as well as progress on project scope, schedule, and budget, will be reported on an annual basis for at least the first 5 years. Section 2 of this document presents the RAOs and describes each of the three remedial technologies and their integration. Section 3 summarizes the Fiscal Year (FY) 2002 technical performance of each remedy component. Section 4 provides a summary of the FY 2002 project scope, schedule, and budget activities.

## 2. REMEDIAL ACTION SUMMARY

### 2.1 Operable Unit 1-07B Remedial Action Objectives

The Agencies have agreed to the following RAOs for the entire contaminant plume. These RAOs, as specified in the *Record of Decision Amendment for the Technical Support Facility Injection Well (TSF-05) and Surrounding Groundwater Contamination (TSF-23) and Miscellaneous No Action Sites, Final Remedial Action* (DOE-ID 2001b), are as follows:

1. Restore the contaminated aquifer groundwater by 2095 (100 years from the signature of the *Record of Decision for the Technical Support Facility Injection Well (TSF-05) and Surrounding Groundwater Contamination (TSF-23) and Miscellaneous No Action Sites Final Remedial Action* [DOE-ID 1995]) by reducing all COCs to below maximum contaminant levels (MCLs) and a  $1 \times 10^{-4}$  total cumulative carcinogenic risk-based level for future residential groundwater use and, for non-carcinogens, until the cumulative hazard index is less than 1.
2. For aboveground treatment processes in which treated effluent will be reinjected into the aquifer, reduce the concentrations of volatile organic compounds (VOCs) to below MCLs and a  $1 \times 10^{-5}$  total risk-based level.
3. Implement institutional controls to protect current and future users from health risks associated with 1) ingestion or inhalation of, or dermal contact with, contaminants in concentrations greater than the MCLs, 2) contaminants with greater than a  $1 \times 10^{-4}$  cumulative carcinogenic risk-based concentration, or 3) a cumulative hazard index of greater than 1, whichever is more restrictive. The institutional controls shall be maintained until concentrations of all COCs are below MCLs and until the cumulative carcinogenic risk-based level is less than  $1 \times 10^{-4}$  and, for non-carcinogens, until the cumulative hazard index is less than 1. Institutional controls shall include access restrictions and warning signs.

The individual remedy performance reports discuss the detail of each remedial components performance against its objectives. This report is a summary of these reports.

### 2.2 Component Descriptions

Figure 2-1 provides a conceptual illustration of the multiple components of the remedy. Figure 2-2 gives a more detailed overview of the TCE plume and the associated zones (hot spot, medial, and distal). Also shown are all the wells in and surrounding the contamination plume. The following sections describe each component and specific objectives and requirements for this reporting period (FY 2002).

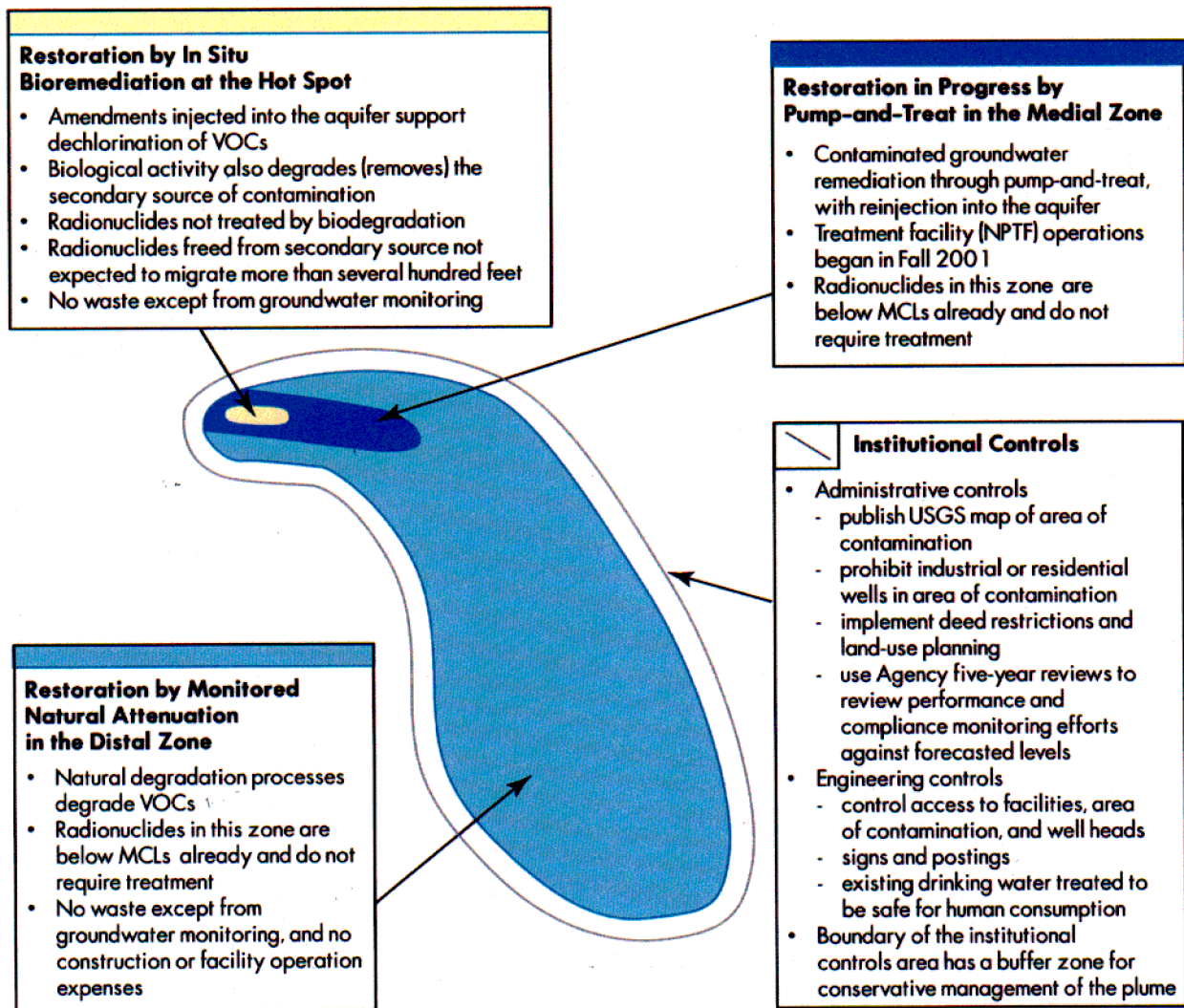


Figure 2-1. Conceptual illustration of the components of the remedy.

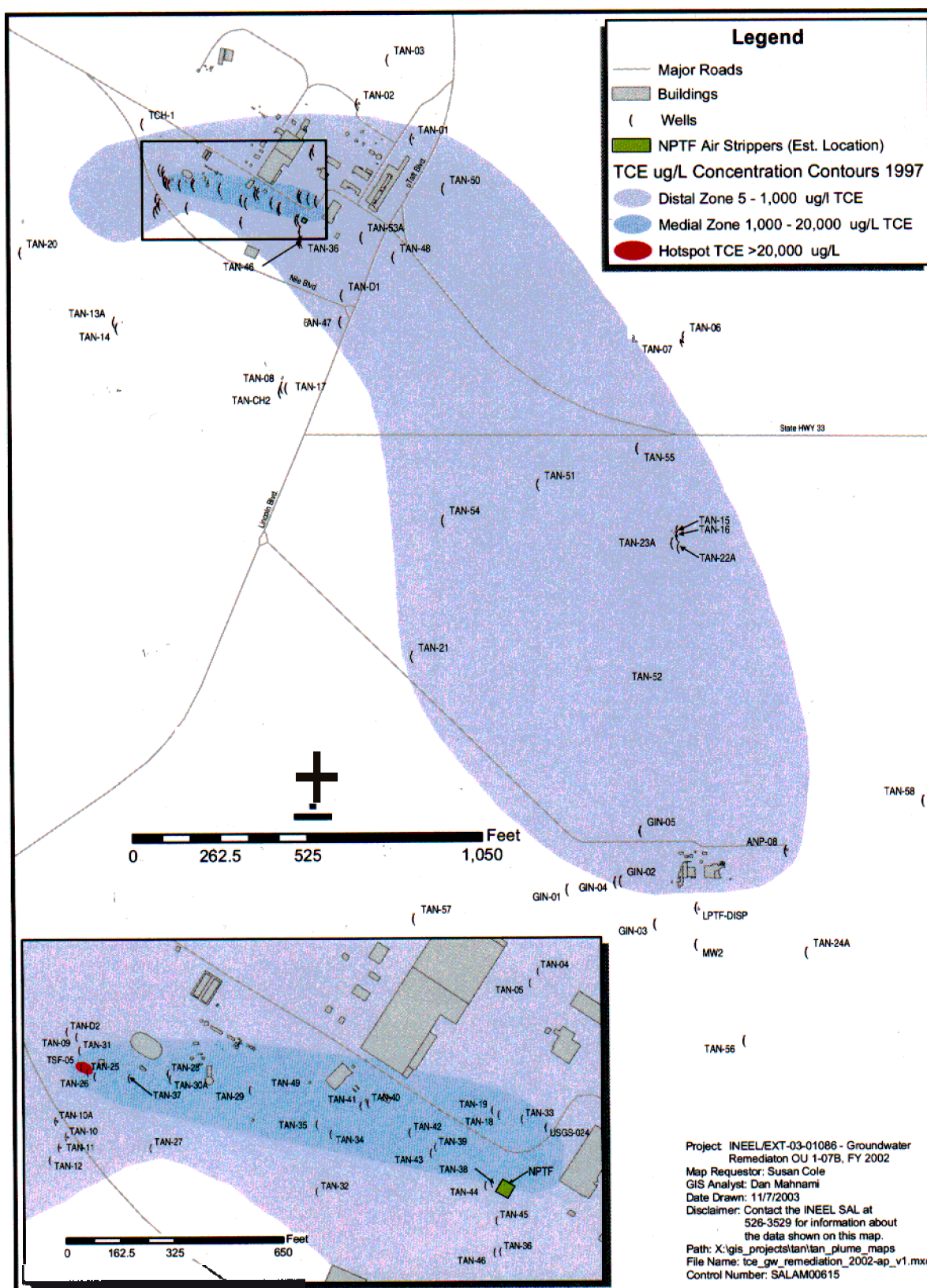


Figure 2-2. Trichloroethene plume and the associated zones,

### 2.2.1 In Situ Bioremediation

In situ bioremediation activities began in November 1998 with a field evaluation to determine whether anaerobic reductive dechlorination (ARD) of TCE could be enhanced through the addition of an electron donor (sodium lactate). Upon successful demonstration, ISB was officially selected as the remedy for the “hot spot,” that is the highly contaminated area in the immediate vicinity of the TSF-05 injection well. Subsequent activities have focused on optimization of the ISB process. The ISB operational timeframe for future activities consists of a phased implementation strategy. The planned timeframe and phase descriptions are shown in Table 2-1.

Table 2-1. In situ bioremediation operational timeframe

Implementation Phases	Planned Timeframe	Phase Description
Predesign Operations (PDO)	May 2001–October 2002	Continue to optimize the ISB remedy (Details are listed in Table 2-2).
Interim Operations	October 2002–September 30, 2003	Continue PDO activities and implement additional activities that support a better understanding of alternate electron donors (AEDs), development of injection strategies that support the Initial Operations Phase, ISB model refinement, and continued ISB lactate addition.
Initial Operations	October 1, 2003–September 30, 2005	Focus on reducing the flux of VOCs from the hot spot in the downgradient direction and gather and analyze data relating to achievement of long-term performance objectives.
Optimization Operations	October 3, 2005–September 30, 2011	Focus on reducing the flux of VOCs from the hotspot in the crossgradient direction while maintaining VOC flux reduction in the downgradient direction, and gather and analyze data relating to achievement of long-term performance objectives.
Long-term Operations	October 3, 2011–TBD (to be determined)	Focus on achievement of hot spot source degradation while maintaining the reduction of VOC flux from the hot spot in the crossgradient and downgradient directions, and gather and analyze data relating to achievement of long-term performance objectives.

Fiscal Year (FY) 2002 activities were conducted as part of Predesign Operations (PDO). PDO were implemented from May 2001 through October 2002, consisting of continued injection of electron donor to achieve the desired distribution and to create conditions for efficient ARD throughout the source zone. Sampling results indicate that the plume has not migrated since operation/monitoring has been underway. The overall goal of the PDO phase was to collect data to support an efficient and cost-effective design for later phases. The specific objectives for FY 2002 ISB activities are summarized in Table 2-2. Descriptions and results of ISB activities for FY 2002 are stated in the *Annual Performance Report for In Situ Bioremediation Operations August 2001 to October 2002, Test Area North Operable Unit 1-07B* (INEEL 2003a). Because ISB was in the PDO phase during FY 2002 and the RD/RA Work Plan had not been finalized, there were no specific regulatory compliance activities required for this reporting period.

Table 2-2. Objectives and activities for the Predesign Operations phase during FY 2002.

Objective	Activities
A. Continue to operate the ISB system to contain and degrade the ISB hotspot	<ul style="list-style-type: none"> <li>Continued ISB system operation (sodium lactate injection and groundwater monitoring).</li> </ul>
B. Maximize cost-effectiveness of TCE dechlorination	<ul style="list-style-type: none"> <li>Optimize electron donor injection volume, concentration, and frequency.</li> <li>Verify effectiveness of injection strategy using groundwater monitoring data.</li> <li>Use modeling to optimize the final ISB treatment system design and operating strategy.</li> </ul>
C. Optimize the sampling frequency and analytes	<ul style="list-style-type: none"> <li>Evaluate the cost effectiveness and utility of each analytical parameter against the data quality objectives (DQOs).</li> <li>Determine the most cost effective sampling frequency to meet the DQOs.</li> </ul>
D. Determine whether sodium lactate injection results in mobilization of metals, strontium, and/or semivolatile organic compounds (SVOCs) from the secondary source (defined as an objective for all Predesign Phases (PDPs) in Appendix E of the ISB Field Evaluation Work Plan [DOE-ID 1998])	<ul style="list-style-type: none"> <li>Continued implementation of ISB system operations.</li> <li>Monitor concentrations of gamma emitters, alpha emitters, metals, strontium, and tritium. (SVOC monitoring was completed prior to this reporting period).</li> </ul>
E. Determine how to better distribute electron donor within the upper part of the aquifer (defined in DOE-ID 1998, Appendix E, for Predesign Phase (PDP) -111)	<ul style="list-style-type: none"> <li>Use modeling to evaluate injection strategies</li> <li>Characterize the changes to the flow and transport system in the source area using a tracer test.</li> <li>If necessary, implement the activities of PDP-III, which would involve the injection of electron donor in Well TAN-37, and/or the use of alternative electron donors (AEDs).</li> </ul>
F. Determine the effectiveness of AEDs relative to lactate for sustaining anaerobic reductive dechlorination reactions within the aquifer (defined in DOE 1998, Appendix E, for PDP-III)	<ul style="list-style-type: none"> <li>Conduct laboratory studies evaluating various AEDs.</li> </ul>

## 2.2.2 New Pump and Treat Facility

Pump-and-treat is being implemented for restoration of the medial zone (Figure 2-1). The NPTF is operated to capture contaminated groundwater across the width of the medial zone portion of the TCE plume. The major components of the pump-and-treat system include a network of extraction wells (TAN-38, TAN-39, and TAN-40), an aboveground treatment system that uses two air strippers to reduce concentrations of VOCs to less than MCLs, and an injection well (TAN-53A) that is used for injecting treated water back into the aquifer. Routine operations of the NPTF began on October 1, 2001

(INEEL 2003b). Design requirements for the NPTF include facility operations 24 hours a day, 7 days per week over the operational period.

Fiscal Year 2002 operational objectives for the NPTF are summarized in Table 2-3. These objectives and activities are discussed in more detail in the *New Pump and Treat Facility Annual Operations Report October 2001 through September 2002 TestArea North Final Groundwater Remedy, Operable Unit 1-07B* (INEEL 2003b).

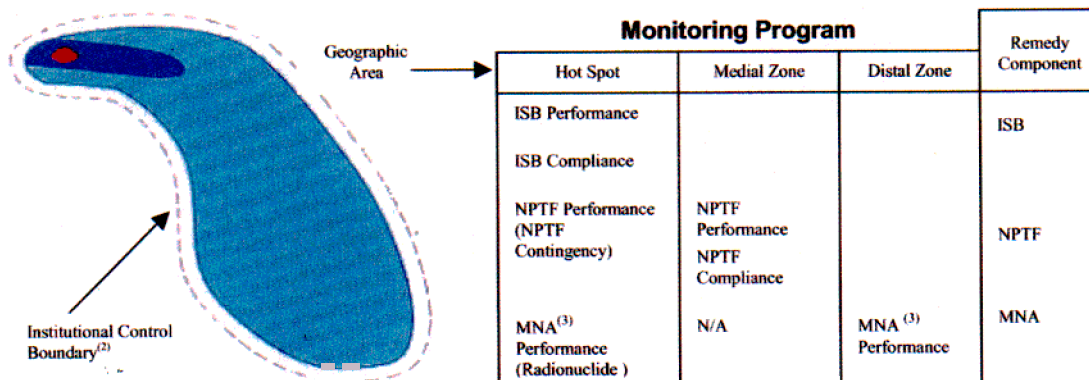
Category	Objectives
Operations	Operational uptime greater than 90% Extraction flowrate between 120 to 250 gpm
Influent, Effluent, and Air Emissions Monitoring	Volatile organic compound and radionuclide concentrations in water discharged from the NPTF must be below MCLs and a $1 \times 10^{-5}$ cumulative carcinogenic risk. Air emissions from the NPTF must be maintained below 0.18 lb/hr for TCE, 4.9 lb/hr for tetrachloroethene (PCE), 564.3 lb/hr for cis-DCE and 0.33 lb/hr for vinyl chloride.
Upgradient Source Control	No requirement for monitoring during FY 2002, but will be added in a revision to the NPTF Remedial Action Work Plan to monitor the concentration of COCs that are upgradient of the extraction well network. The purpose is primarily to provide sufficient warning so that operational changes can be made if groundwater with higher than anticipated contaminant concentrations is moving toward the extraction wells.

### 2.2.3 Monitored Natural Attenuation

Monitored natural attenuation is being implemented for restoration of the distal zone (Figure 2-3). Groundwater monitoring over the past decade has shown little or no increase in TCE concentrations downgradient from TSF-05. These observations suggest that a biodegradation mechanism is operational in the aerobic distal zone of the TCE plume. Through a series of site investigations, scientific studies, and regulatory activities, MNA was evaluated and selected as a remedy to address portions of the groundwater plume contaminated at levels below 1,000 µg/L TCE (DOE-ID 2001b).

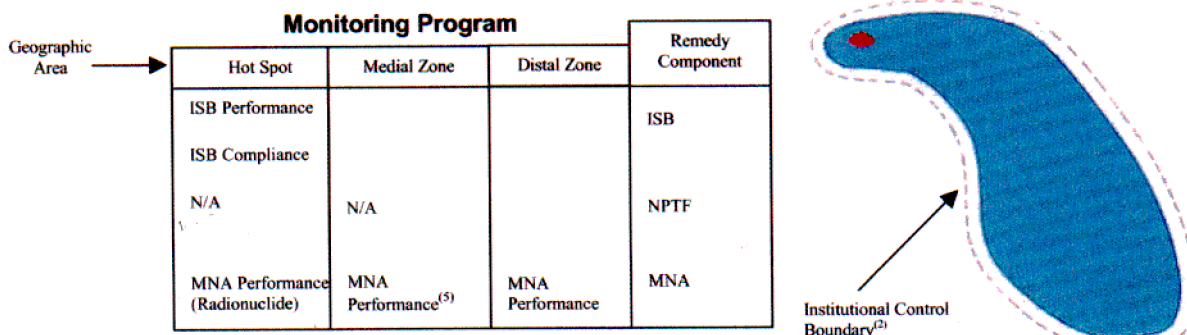
**2001–2015<sup>(1)</sup>**

Operations during this period consist of ISB at the hot spot, NPTF at the medial zone, and MNA in the distal zone. It is assumed that ISB has successfully achieved the completion criteria for performance operations, which consist of stopping VOC flux from the hot spot.



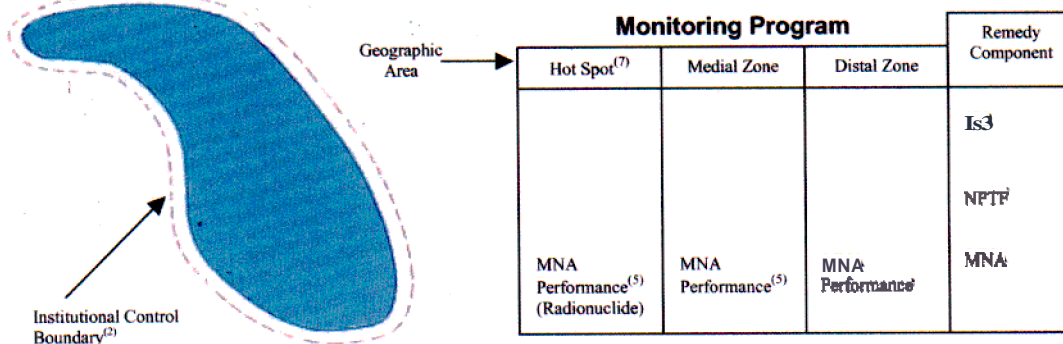
Operations during this period consist of ISB at the hot spot and MNA for the distal zone<sup>(4)</sup>. It is assumed that the NPTF has successfully achieved the medial zone completion criteria and is in standby mode.

**2016–2020<sup>(1)</sup>**



**2021–2095<sup>(1)(6)</sup>**

Operations during this period consist of MNA in the distal zone<sup>(4)</sup>. It is assumed for this period that ISB has successfully achieved the completion criteria for long-term operations and not only has the flux been cut off, but the source has been degraded.



1. The dates and the shape of the plume shown are for illustrative purposes only.
2. The institutional control boundary extends 40% beyond the current dimensions of the plume; expansion accounts for 30% and a buffer zone accounts for 10%. 30% plume expansion is allowed in the ROD (DOE-ID, 2001b).
3. The MNA compliance requirements during this period consist of annual monitoring for at least the first 5 years.
4. The distal zone is defined as the areal extent of the plume that is less than 1,000 µg/L TCE and greater than 5 µg/L TCE.
5. The MNA monitoring program will be expanded to include additional wells to be monitored for MNA performance parameters.
6. Assumes the hot spot has been removed.
7. In situ bioremediation or some yet-to-be-determined technology will operate at the hot spot until hot spot RAOs are achieved.

Figure 2-3. Generalized monitoring program operations throughout the remedy timeframe.

Because MNA was not considered an active remedial component during FY 2002 and the RD/RA Work Plan had not been finalized, there were no specific regulatory compliance activities for this reporting period. Groundwater sampling was conducted during FY 2002 under the *Phase C Groundwater Monitoring Plan, Test Area North Operable Unit 1-07B* (INEEL 2002a), which specified wells to be sampled and parameters for analysis. The data collected will be used to evaluate MNA performance.

Specific objectives and groundwater monitoring and data analysis requirements for operations in subsequent years are established in the *Monitored Natural Attenuation Remedial Action Work Plan for Test Area North Final Groundwater Remediation, Operable Unit 1-07B* (DOE-ID 2003b). The objectives defined in the work plan are described below.

Compliance Objectives:

- Conduct groundwater monitoring at all MNA performance-monitoring wells at a frequency and duration sufficient to demonstrate that the remedy is operational, functional, and effective.
- Demonstrate at the end of the remedial action period that RAOs for groundwater have been attained.

Performance Objectives:

- Monitor whether the natural attenuation process continues to trend toward RAOs for the distal zone of the plume.
- Monitor plume expansion.

The MNA operational timeframe for future activities consists of a phased implementation strategy. The planned timeframe and phase descriptions are shown in Table 2-4.

Table 2-4. Monitored natural attenuation operational timeframe.

Implementation Phases	Planned Timeframe	Phase Description
Performance Operations	2003 – 2013	Annual sampling and analysis to confirm that TCE is being transported and degraded as expected. Actual duration of the performance phase may be adjusted by the Agencies based on data results.
Long-term Operations	2014 – 2095	Periodic groundwater monitoring to track the remedy's progress toward achieving the RAOs.

## 2.3 Component Integration

The OU 1-07B remedy is unique in that multiple technologies were brought to bear on a single contaminated groundwater plume. In situ bioremediation was applied to reduce contaminant concentrations in the source area, the NPTF was initiated to capture and clean contaminated water in the medial zone, and MNA is expected to provide an efficient and cost-effective technique to bring residual contamination throughout the entire plume to below regulatory levels within the duration of the remedial action period. Each component controls the flux of contamination into the next remediation zone, resulting in overall impacts to the plume concentrations. As illustrated in Figure 2-3, as the contaminant levels are reduced over time, the active remedial components (ISB and NPTF) will be phased out. Upon

completion of ISB and NPTF operations, MNA will continue throughout the plume to meet the RAO by 2095.

In FY 2002, the design of each remedial action component was evaluated and, for each monitoring zone, the monitoring types, sample parameters, decision/evaluation objective, goals, sample programs, and requirements basis were identified through completion of the remedy. Table 2-5 provides a crosswalk of the requirements and activities for each of the three monitoring zones.

Table 2-5. Monitoring crosswalk table for the Operable Unit 1-07B groundwater remediation remedy.

Monitoring Zone	Monitoring Type	Sample Parameter	Decision/Evaluation Objective	Goal	Sample Program	Basis Document
Hot spot	ISB performance	ISB performance parameters: <ul style="list-style-type: none"> <li>• VOCs</li> <li>• Tritium</li> <li>• Ethene, ethane, methane, redox, electron donor, bioactivity, and nutrient</li> </ul>	Trending <ul style="list-style-type: none"> <li>• Donor distribution</li> <li>• Source degradation</li> <li>• Flux</li> <li>• New donor</li> </ul>	Optimize operation to meet compliance objectives/requirements.	ISB	ISB Work Plan (DOE-ID 2003a)
	ISB compliance	VOCs (TAN-28 and TAN-30A)	VOCs below MCLs for 1 year	Achieve reduction of downgradient flux to below MCLs.	ISB	ISB Work Plan (DOE-ID 2003a)
		VOCs (TAN-1860 and TAN-1861)	VOCs below MCLs for 1 year	Achieve reduction of cross-gradient flux to below MCLs.	—	—
	ISB completion compliance	All VOCs (wells TBD)	Hot spot completion	Determine whether ISB RAOs have been met in the hot spot.	ISB	ISB Remedial Action Report (pending)
	NPTF performance	VOCs plus radionuclides (strontium, cesium) (wells TBD)	Upgradient source	NPTF contingency evaluation monitoring	NPTF	NPTF Work Plan (DOE-ID 2003c)
	MNA performance	Radionuclides (strontium and cesium; TAN-25, TAN-37, TAN-28, TAN-30A, TAN-29, and TSF-05)	Upgradient radionuclide monitoring (hot spot)	Monitor/evaluate hot spot radionuclide degradation and migration.	MNA	MNA Work Plan (DOE-ID 2003b)
Medial zone	NPTF performance	Draw down	Facility operations	Plume capture	NPTF	NPTF Work Plan (DOE-ID 2003c)
	NPTF compliance	Facility influent/effluent VOCs and strontium	Facility operations	Stay within influent and effluent specifications.	NPTF	NPTF Work Plan (DOE-ID 2003c)
	NPTF completion compliance	Air emissions	Facility operations	Stay within effluent specifications.	—	—

Table 2-5 (continued).

Monitoring Zone	Monitoring Type	Sample Parameter	Decision/Evaluation Objective	Goal	Sample Program	Basis Document
Medial zone (continued)	NPTF completion compliance (continued)	Operations uptime	Facility operations	Maintain 90% uptime.	—	
		Extraction flow rate	Facility operations	Operate within specified flow rate.	—	NPTF Work Plan (DOE-ID 2003c)
		All COCs (wells TBD)	Medial zone completion	Determine that NPTF RAOs have been or can be met in the medial zone.	NPTF	—
Distal zone	MNA performance	MNA performance parameters: <ul style="list-style-type: none"><li>• TCE</li><li>• DCE</li><li>• PCE</li><li>• VC</li><li>• Tritium</li></ul>	Breakthrough curves	Trends are toward achievement of RAOs.	MNA	MNA Work Plan (DOE-ID 2003b)
	MNA compliance	MNA performance parameters for 5 years	Plume expansion	—	—	—
			Degradation rate	Annual sampling is a requirement for at least the first 5 years.	MNA	MNA Work Plan (DOE-ID 2003b)
	MNA completion compliance	All COCs	MNA performance parameters	Determine that RAOs have been met throughout the plume.	MNA	MNA Remedial Action Report (pending)
			Remedial action completion	—	—	—

COC = contaminant of concern  
DCE = dichloroethene  
ISB = in situ bioremediation  
MCL = maximum contaminant level  
MNA = monitored natural attenuation  
NPTF = New Pump and Treat Facility  
PCE = tetrachloroethene

RAO =remedial action objective  
TAN = Test Area North  
TBD =to be determined  
TCE = trichloroethene  
VC = vinyl chloride  
VOC = volatile organic compound

### 3. 2002 REMEDY PERFORMANCE

The three components of the final groundwater remedy are in the beginning stages of operations. The NPTF went online at the start of FY 2002. ISB and MNA are scheduled for prefinal inspection in Fall 2003. This section summarizes the technical performance for each component during FY 2002. Overall, initial performance data are consistent with expectations. Detailed information is available in the FY 2002 annual reports for each component.

#### 3.1 In Situ Bioremediation

The ISB pre-design operational objectives (listed in Section 2, Table 2-2) were successfully met during FY 2002. Activities performed to meet the objectives were reported in the *Annual Performance Report for ISB Operations August 2001 to October 2002, Test Area North Operable Unit 1-07B* (INEEL 2003a). The sections below provide a summary of FY 2002 ISB activities, and an indication of which objective(s) was addressed (see Table 2-2).

##### 3.1.1 Operations

- Performed seven sodium lactate injections at various volumes, concentrations, and frequencies. These differing injections had distinct effects on the distribution of electron donor, the electron donor utilization, the redox conditions, and ARD efficiency within the treatment area; yet it is still recommended that an alternate injection strategy, possibly including installation of an additional injection well at the presumed downgradient edge of the residual source, remains necessary to achieve TAN ISB performance objectives (Objectives A and B in Table 2-2).
- Investigated the use of alternate electron donors (AEDs) other than sodium lactate that might be equally effective in terms of stimulating ARD, while at the same time being more cost effective. Laboratory studies on a number of AEDs were conducted to determine the ARD efficiency and cost-effectiveness, the interfacial tension (IFT) between the AED solution and TCE, the impact of AED on the microbial community, and the metals content of the AED injected solution (Objectives A and B).
- Monthly monitoring of 14 wells with an average of 96.9% completion (Objectives A and B).

##### 3.1.2 Optimization Studies

- Groundwater modeling was used to create a predictive tool that can be used to simulate chemical oxygen demand (COD) distribution under various injection strategies (Objectives B and E in Table 2-2).
- Recommendations were made to reduce the number of VOC split sample collections from four times per year to two times per year, and to eliminate the collection of ethene/ethane/methane splits until the beginning of long-term operations (Objective C in Table 2-2).
- Concentrations of gamma emitters, alpha emitters, metals, and strontium were monitored at seven wells, and the results indicate that ISB activities have not resulted in enhanced migration above acceptable levels. While there are some examples of elevated concentrations in a localized area surrounding the TSF-05 injection well, all concentrations consistently decrease with distance from TSF-05 (Objective D in Table 2-2).

- A tracer test was performed from July 29 to August 8, 2002 to characterize changes to the flow and transport system for data to support developing a predictive modeling tool that would test various electron donor injection strategies. These tracer test data were compared to those from the 1998 tracer test to identify changes in porosity as a result of 4 years of ISB operations. The 2002 data, while not entirely conclusive, do appear to suggest that the effective porosity along the flowpath from TSF-05 to TAN-25 may have increased relative to 1998 values, while the effective porosity values along the flowpath from TSF-05 to TAN-31 were relatively similar to 1998 values (Objective E in Table 2-2).
- Laboratory studies were conducted to evaluate alternative electron donors (AEDs), both for cost-effectiveness and ARD efficiency. Studies included interfacial tension (IFT) and molecular and metal analysis (Objectives C and F in Table 2-2).

## 3.2 New Pump and Treat Facility

Details for FY 2002 NPTF activities were reported in the *New Pump and Treat Facility Annual Operations Report October 2001 to September 2002, Test Area North Final Groundwater Remedy, Operable Unit 1-07B* (INEEL 2003b). Conclusions from the annual report are summarized below.

### 3.2.1 Operations

- The NPTF operated within required limits throughout FY 2002. These limits include operational uptime (met with 98.4% uptime) and extraction well flowrate (reported between required limits, except for brief shutdown periods).
- Purge water processed by the NPTF during FY 2002 was handled according to applicable procedures.
- Routine inspections were performed as required

### 3.2.2 Influent, Effluent, and Air Emissions Monitoring

- Contaminant of concern (COC) concentrations in NPTF influent declined throughout FY 2002
- Effluent concentrations of COCs, including both VOCs and radionuclides, were below MCLs throughout FY 2002. The cumulative carcinogenic risk because of VOCs that are COCs was less than the  $1 \times 10^{-5}$  requirement throughout the fiscal year.
- Two independent calculations of VOC mass discharge concluded that the mass flowrates of each VOC discharged from the NPTF air strippers to the atmosphere were within regulatory requirements.

### 3.2.3 Plume Capture

- The hydraulic response of four wells near the edge of the capture zone (TAN-19, TAN-32, TAN-33, and TAN-36) was monitored during planned and unplanned shutdowns and restarts for the first three quarters of FY 2002. There were no extraction well shutdowns during the fourth quarter and hence, drawdown due to pumping from the extraction wells was not assessed during the fourth quarter.

- Water levels in the four wells near the edge of the capture zone responded to extraction shutdown and startup. Drawdown in these wells indicates that the minimum required capture zone width has been achieved.

### **3.2.4 Upgradient Source Control**

- Concentrations of COCs in TAN-29 indicated temporal trends of water approaching the extraction wells.
- Concentrations of COCs other than PCE and TCE either remained steady or declined.
- Concentrations of PCE and TCE at TAN-29 increased slightly during FY 2002. The PCE and TCE trends may result from previous operations of the Air Stripper Treatment Unit (ASTU). This increase is not expected to affect NPTF operations, and no changes to the operating strategy are needed.

### **3.2.5 Baseline Facility Performance**

- Concentrations of COCs were monitored quarterly in wells TAN-33, TAN-36, TAN-43, and TAN-44.
- Concentrations of COCs other than tritium decreased downgradient from TAN-29 in wells TAN-33, TAN-36, TAN-43, and TAN-44. Tritium concentrations were approximately the same in all wells monitored.
- For the hydraulic performance, the extraction and injection wells did not show any signs of declining transmissivity during FY 2002.

## **3.3 Monitoring and Natural Attenuation**

Preremedial action data collection activities were completed under Phase C requirements as reported in the *Fiscal Year 2002 Groundwater Monitoring Annual Report, Test Area North, Operable Unit 1-07B* (INEEL 2003c). Data analyses were also conducted to support the writing of the RD/RA Work Plan (submitted in March 2003). The results of these analyses, as well as results of groundwater monitoring work, are summarized below:

Fiscal Year 2002 activities are also stated in the Annual Fiscal Year 2002 Groundwater Monitoring Report (INEEL 2003c). Results of groundwater monitoring data are presented, summarized, evaluated, and interpreted with historical data. In addition, TAN well maintenance activities are included to document the integrity of the monitoring well network and to provide additional information that may be necessary for analytical data interpretation.

### **3.3.1 Groundwater Monitoring**

- Post-breakthrough TCE concentration trends will not be formally assessed until later during the performance operations phase when sufficient monitoring data become available. However, the existing data at one location (United States Geological Survey (USGS)-24) indicate that natural attenuation of TCE is occurring as expected. A long-term monitoring and evaluation strategy was developed and will be finalized in the *Monitored Natural Attenuation Remedial Action Work Plan for Test Area North Final Groundwater Remediation, Operable Unit 1-07B* (DOE-ID 2003b).

- Fiscal Year 2002 data indicate that radionuclide concentrations in the distal portion of the plume are below their respective MCLs. Radionuclide concentrations collected from wells near TSF-05 indicate that sorption processes are already having a measurable effect on radionuclide concentrations. For example, the observed decline in Sr-90 concentrations is 40 times greater than what can be attributed to radioactive decay alone, indicating that sorption or other geochemical processes are reducing radionuclide concentrations in groundwater. Sr-90 concentrations also decline along the plume axis at greater distances from TSF-05 (INEEL, 2003c).
- Data collected from the existing monitoring well network from 1997 through 2002 indicate that the size and shape of the 5- $\mu\text{g/L}$  isopleth (the plume boundary) has not changed significantly. Comparison of 2002 water-level data to past water-level data show that the groundwater flow field has not changed significantly, with the exception of a groundwater mound that has formed in response to extraction/injection of water as a result of NPTF operations.
- Stratified samples were collected from four **MNA** wells that have been fitted with multiport Flexible Liner Underground Technology (FLUTE™) samplers. The data show well-to-well variability, demonstrating that vertical concentration profiles are a function of local stratigraphy, as opposed to large-scale preferential flow or attenuation processes acting at different rates with depth.
- Prior to the start of the NPTF, TCE concentrations from wells located near the downgradient boundary of the medial zone were consistently less than 1,000  $\mu\text{g/L}$ , indicating that groundwater in this area would meet operational parameters of the **MNA** component of the remedy.

### 3.3.2 Data Analyses

- TCE and cis-DCE biodegradation rates were estimated using the tracer-corrected method (Sorenson et al. 2000). The tracer-corrected method compares changes in contaminant concentrations to changes in concentrations of environmentally conservative tracers (e.g., tritium) at varying points throughout the plume to assess contaminant degradation independently of the effects of geohydraulic processes such as dispersion. Results of the analyses yielded an estimate of a TCE half-life of 13.2 years and an estimate of a cis-DCE half-life of 8.4 years, which is consistent with earlier predictions.
- The **MNA** groundwater flow and transport model developed using TETRAD, a three-dimensional petroleum engineering/geothermal simulator model, was converted to a MODFLOW/MT3DMS format. The updated model will support ongoing evaluation of concentration trends to ensure that the groundwater RAO will be met within the remedial action period.

## 3.4 2002 Combined Remedy Performance

Based on the results of FY 2002 remedial activities, the combined OU 1-07B remedy appears to be effective. Even though the three components are in early phases, they appear to be sufficiently integrated, and initial performance trends are on track with the expected long-term trends.

The OU 1-07B remedy is unique in that multiple technologies were brought to bear on a single contaminated groundwater plume. In situ bioremediation was applied to quickly reduce contaminant concentrations in the source area, the NPTF was initiated to minimize downgradient transport of contaminated water, and **MNA** is expected to provide an efficient and cost-effective technique to bring residual contamination to below regulatory levels within the duration of the remedial action period. Each

component controls the flux of contamination into the next remediation zone, resulting in overall impacts to the plume concentrations. As illustrated in Figure 2-3, as the contaminant levels are reduced over time, the active remedial components (ISB and NPTF) will be phased out. Upon completion of ISB and NPTF operations, MNA will continue throughout the plume to meet the RAO by 2095.

### 3.4.1 ISB Performance Summary

In general, the ISB system operated effectively during FY 2002, stimulating ARD throughout most of the source area. The 4 years of sodium lactate injection and resulting biological activity in the TSF-05 area have resulted in the destruction of source material, as indicated by changes in the effective porosity, based on results of the tracer test and modeling activities, and the observed groundwater mounding which surrounds well TSF-05. The implication of this conclusion is that the ISB remedy is actively reducing the source of contamination at the TSF-05 hotspot. Downgradient, the response in redox conditions in TAN-37A and TAN-28 indicated that the large volume injections had some impact on the downgradient portion of the source; however, the continued flux of sulfate and TCE to these wells indicates that the size of the biologically active zone does not fully encompass the entire residual source in the downgradient direction.

### 3.4.2 NPTF Performance Summary

During FY 2002, compliance monitoring included collecting samples from the NPTF influent sampling port, SP-1. All contaminant concentrations entering the NPTF through SP-1 have decreased over the timeframe of FY 2002. The ranges of the concentration from October 2001 through September 2002, including peak highs and lows, are shown in Table 3-1. Concentrations of VOCs and tritium in NPTF influent samples generally showed an overall trend of declining concentrations with a large amount of scatter about this general trend. In contrast, strontium concentrations did not have an obvious trend but were variable. Gross alpha and gross beta measured in the NPTF influent did not exhibit a discernable trend but merely variation about a stable concentration. Throughout the fiscal year, Sr-90 was at or below detection limits and there was no discernible trend.

From Table 3-1 it is evident that the influent TCE concentrations to the treatment unit (from extraction wells TAN-38, TAN-39, and TAN-40) are an order of magnitude lower than the original design basis. It is unclear whether this is due to influence of noncontaminated water from outside the plume being caught by the NPTF extraction wells, or whether the ambient concentrations within the medial zone are actually that low. A rebound study to determine ambient medial zone concentrations should be considered in upcoming years.

Table 3-1. New Pump and Treat Facility influent concentrations at SP-1 during FY 2002.

COC	Concentration in October 2001	Concentration in September 2002 <sup>a</sup>	Concentration Peak (month/year)	Concentration Low (month/year)
TCE (µg/L)	310	155	380 (December 2001)	100 (August 2002)
PCE (µg/L)	26	13	35 (November 2001)	11 (June 2002)
cis-DCE (µg/L)	36	8	14 (November 2001)	2 (August 2002)
trans-DCE (µg/L)	13	3	35 (October 2001)	3 (September 2002)

Table 3-1. (continued).

COC	Concentration in October 2001	Concentration in September 2002 <sup>a</sup>	Concentration Peak (month/year)	Concentration Low (month/year)
Tritium (pCi/L)	3,540	2,435	3,700 (January 2002)	2,435 (September 2002)

a. All concentrations expressed as an average of duplicate values.

### 3.4.3 Performance Summary

Water-chemistry data collected during FY 2002 MNA activities were analyzed in support of the upcoming evaluation and reporting activities of the MNA remedial action. These data collection and analytical activities document operational conditions before MNA remedial action and support future interpretation of monitoring data. The highlights of this activity are summarized below:

- Historic TCE concentration data indicated that a decreasing trend in concentration can be clearly defined in the post-breakthrough TCE data set at well USGS-24. Locations further downgradient are expected to have lower and broader concentration peaks with very gradual reductions in concentration over long time periods.
- The observed degradation rates for TCE and cis-DCE were estimated to be 13.2 years and 8.4 years, respectively. This indicates that degradation of cis-DCE is occurring in concert with TCE degradation at a faster rate, as expected from its properties.
- During FY 2002, stratified samples were collected from four MNA wells (TAN-51, -52, -54, and -55) that had been fitted with multiport FLUTE<sup>TM</sup> samplers. The similar profiles detected for several analytes in the FLUTE<sup>TM</sup> wells demonstrate the overall consistency of the FLUTE<sup>TM</sup> data. The well-to-well variability demonstrates that vertical concentration profiles are a function of local stratigraphy, as opposed to large-scale preferential flow or attenuation processes acting at different rates with depth.
- Data collected since 1997 indicate that the size and shape of the 5-μg/L isopleth that defines the plume boundary have been relatively stable.
- Radionuclide concentrations were monitored in selected wells near TSF-05 to verify the assumption that radionuclides will attenuate naturally through the process of sorption and radioactive decay to meet cleanup objectives throughout the plume. The data indicate that natural attenuation processes already are having a measurable effect on radionuclide concentrations at some locations. Tritium concentrations for all MNA wells are presently less than the MCL.

To further corroborate the expected performance of MNA, additional FY 2002 studies by the OU 1-07B project and the Department of Energy's Subsurface Contaminants Focus Area have investigated a technique to directly detect biodegrading activity throughout the contaminated plume. The method utilizes enzyme probes that react with the active site of enzymes that are known to co-metabolize TCE. The probes themselves are colorless, but the product of the reaction between the probes and the enzyme is fluorescent. Detection of the fluorescent product in the cells after the probe has been applied is direct evidence that the enzyme is present and active. Verification of naturally occurring and persistent biological activity will potentially provide near-term corroboration of MNA's ability to achieve RAOs in the distal and medial zones of the plume.

## 4. 2002 PROJECT PERFORMANCE

Required scope, schedule, and budget for implementation of the OU 1-07B remedy is detailed in the ROD Amendment (DOE-ID 2001b), Statement of Work (DOE-ID 2001a), and RD/RA Work Plans (DOE-ID 2003a, 2003b, 2003c). Table 4-1 identifies FY 2002 required and completed activities for all three remedial action components. (No compliance monitoring was required for ISB during FY 2002.) Table 4-2 lists the required deliverables, enforceable submittal date, and actual submittal date.

Table 4-1. Required activities during FY 2002.

Requirement	Completed Activity
NPTF 120 to 250 gpm flowrate and 90% uptime	Operational uptime was greater than 98%; Extraction flowrate was maintained between the limits throughout the fiscal year, except during planned or unplanned shutdown periods.
NPTF Compliance Monitoring	Influent and effluent monitoring per <i>Sampling and Analysis Plan for the New Pump and Treat Facility Performance Monitoring Test Area North, Operable Unit 1-07B</i> (INEEL 2001).
Annual Groundwater Sampling	Groundwater sampling per <i>Phase C Groundwater Monitoring Plan, Test Area North Operable Unit 1-07B</i> (INEEL 2002a).

Table 4-2. Required deliverables during FY 2002.

Deliverable	Enforceable Date	Actual Date
NPTF Remedial Action Report	August 2002	August 2002
ISB RD/RA Work Plan	July 2002	July 2002
ISB Technical and Functional Requirements	March 2002	March 2002

The project was adequately funded to accomplish all required work, as well as a number of scientific and engineering tasks necessary to ensure effective and compliant operations in upcoming years.

In summary, the OU 1-07B project completed all operational and monitoring activities required for the NPTF and MNA remedies. The project met all enforceable milestones for submittal of primary and secondary documents. The combined FY 2002 accomplishments will ensure a successful start of operations and will ultimately support attainment of remedial action objectives.

## 5. WASTE INVENTORY SUMMARY

The waste inventory information shown in Table 5-1 summarizes the waste stored in the CERCLA Waste Storage Units during Fiscal Year 2002.

Table 5-1. Fiscal Year 2002 waste inventory.

Catenorv	Waste	Unit	Generated	Currently Stored	Removed
1	Bag filter, PPE, and miscellaneous	55-gal drum	0	16	0
2	Spent carbon	55-gal drum	0	0	0
3	Spent resin	55-gal drum	1	7	0
4	TAN-31 drill cuttings	2 × 4 × 8 ft box	0	5	0
5	GWTF piping and parts	4 × 4 × 8 ft box	0	4	0
6	Brass material	10-gal drum	0	1	0
7	Tracer test material	55-gal drum	0	2	0
8	Bag filter rings	55-gal drum	0	1	0
9	ISB test kits waste	55-gal drum	1	5	0
10	Miscellaneous wastes	30-gal drum	0	1	0
11	Sampling equipment	55-gal drum	0	1	0
12	Multimedia filter material	55-gal drum	3	3	0

## 6. REFERENCES

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